[Document Name] Specification

[Reference Number] 2913040500

[Submission Date] September 20, 2002

[Addressee] Patent Office Commissioner

[Int'l Patent Classification] B41J 2/44

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[Display of Handling Fee]

[Prepayment Registration Number] 011305

[Amount of Payment] 21,000 yen

[List of Submitted items]

[Item Name] 1 Specification

[Item Name] 1 Set of Drawings

[Item Name] 1 Abstract

[Number for Comprehensive Power of Attorney] 9809938

[Document Name] Specification

[Title of Invention] Organic electroluminescence element and an exposure unit and image-forming apparatus both using the element

[Claims]

1. An organic electroluminescence element comprising, on a substrate:

an anode which acts as a hole injection electrode;

a cathode which acts as an electron injection electrode;

a first and a second light emission layers each having a light emission region and being arranged between said anode and said cathode, said first light emission layer being arranged close to said anode, said second light emission layer being arranged close to said cathode; and

a charge generation layer which injects electrons into the first light emission layer and holes into the second light emission layer, said charge generation layer being arranged between said first and second light emission layers,

wherein the work function of said charge generation layer is configured higher than the ionization potential of said second light emission layer.

2. An organic electroluminescence element comprising, on a substrate:

an anode which acts as a hole injection electrode;

a cathode which acts as an electron injection electrode;

a first and a second light emission layers each having a light emission region and being arranged between said anode and said cathode, said first light emission layer being arranged close to said anode, said second light emission layer being arranged close to said cathode; and

a charge generation layer which injects electrons into the first light emission layer and holes into the second light emission layer, said charge generation layer being arranged between said first and second light emission layers,

wherein the electron affinity of said charge generation layer is configured lower than the electron affinity of said first light emission layer, and wherein the ionization potential of said charge generation layer is configured higher than the ionization potential of said second light emission layer.

3. An organic electroluminescence element comprising, on a substrate:

an anode which acts as a hole injection electrode;

a cathode which acts as an electron injection electrode;

a first and a second light emission layers each having a light emission region and being arranged between said anode and said cathode, said first light emission layer being arranged close to said anode, said second light emission layer being arranged close to said cathode; and

a charge generation layer which injects electrons into the first light emission layer and holes into the second light emission layer, said charge generation layer being arranged between said first and second light emission layers,

wherein the potential difference between the electron affinity of said first light emission layer and said charge generation layer, and the potential difference between the ionization potential of said second light emission layer and said charge generation layer are both configured 0.6 eV or less.

4. The organic electroluminescence element according to one of claims 1, 2, and 3, in which said charge generation layer comprises at least a first generation layer lying in the side of said first light emission layer and a second generation layer lying in the side of said second light emission layer, wherein said first generation layer is configured at a lower electron affinity compared to that of said second generation layer, and said second generation layer is configured at a higher ionization potential compared to that of said first generation layer.

5. The organic electroluminescence element according to claim 4, wherein the generation layer which is first fabricated is prepared by resistive heating.

6. The organic electroluminescence element according to one of claims 1 through 5, wherein said charge generation layer is made of a dielectric material and the relative permittivity of said charge generation layer is larger than that of said first and second light emission layers.

7. The organic electroluminescence element according to one of claims 1 through 6, wherein said first light emission layer and said second light emission layer are mutually made of the same material.

8. An exposure unit which uses the organic electroluminescence element according to one of claims 1 thorough 7 as a light source.

9. An exposure unit which uses an organic electroluminescence element as a light source, said element comprising, on a substrate:

an anode which acts as a hole injection electrode;

a cathode which acts as an electron injection electrode;

a first and a second light emission layers each having a light emission region and being arranged between said anode and said cathode, said first light emission layer being arranged close to said anode, said second light emission layer being arranged close to said cathode; and

a charge generation layer which injects electrons into the first light emission layer and holes into the second light emission layer, said charge generation layer being arranged between said first and second light emission layers.

10. The exposure unit according to claim 9, wherein said first light emission layer and said second light emission layer are mutually made of the same material.

11. The exposure unit according to one of claims 8, 9, and 10, wherein the layer that includes said light emission layers arranged between an initially fabricated electrode and said charge generation layer and that is arranged adjacent to said charge generation layer is made of a high polymer material.

12. An exposure unit utilizing, as a light source, an organic electroluminescence element comprising, on a substrate:

a plurality of anodes which act as hole injection electrodes;

a plurality of cathodes which are arranged alternately with said anodes and act as electron injection electrodes; and

a plurality of light emission layers each having a light emission region and arranged between said anode and said cathode.

13. The exposure unit according to claim 12, wherein the layer that includes said light emission layer arranged between an initially fabricated electrode and a subsequently fabricated electrode is made of a high polymer material.

14. The exposure unit according to one of claims 8 through 13, wherein the organic electroluminescence element is driven by one of alternating current, alternating voltage and wave pulse.

15. The exposure unit according to claims 8 through 14, wherein an exposure

light is retrieved from a side of the organic electroluminescence element.

16. An image-forming apparatus comprising:

the exposure unit according to one of claims 8 through 15; and

a photoreceptor in which an electrostatic latent image is formed by said exposure unit.

[Detailed Description of Invention]

[Technical Field]

[0001] The present invention relates to an organic electroluminescence element used for a light emission device in various apparatuses and an exposure unit as well as an image-forming apparatus using the element.

[Background Technology]

[0002] An electroluminescence element is a light emission device using electric field-induced light emission of a solid luminescent material. Now, inorganic electroluminescence elements that use inorganic materials as the light emitter are in practical use, and expansion of their applications to the backlight for liquid crystal displays or flat panel displays are intended in some segments. However, the voltage required for the light emission of inorganic electroluminescence elements is rather high, i.e., 100 v or higher. In addition, due to the difficulty in blue light emission, it is difficult to achieve full color emission based on the three primary colors of R, G and B. Moreover, since the refractive index of the material used as the light emitter of an inorganic electroluminescence element is very high, the emission light is strongly affected by the effect of the total reflection at boundaries. Accordingly, the efficiency of taking out the actually emitted light into the air is as low as roughly 10 to 20%, which value is difficult to improve.

[0003] On the other hand, studies on electroluminescence elements using organic materials have called attention for a long time. Though various investigations have been made, they never evolved to a full-scale study for practical use because the emission efficiency was extremely low.

[0004] But, in 1987, C. W. Tang et al of Kodak Co. proposed an organic electroluminescence element having a function-separated, stacked structure in which the organic material is divided into two layers, i.e., a hole transport layer and a light emission layer. And it has become evident that, in spite of a low voltage of 10 V or lower, an emission luminance as high as 1000 cd/m^2 or more is attained (Refer to C. W. Tang and S. A. Vanslyke; Applied Physics Letter (Appl. Phys. Lett.) (USA), Vol. 51, 1987, p. 913.). Since then, organic electroluminescence elements have attracted attention on a sudden. Still now, function separation type organic electroluminescence

elements having a similar stacked structure are being actively studied. In particular, efficiency enhancement and life expansion, which are indispensable for the product development of organic electroluminescence elements, are also being thoroughly investigated, resulting in the recent development of displays using organic electroluminescence elements.

[0005] Now, the structure of a conventional, common organic electroluminescence element will be explained with reference to Fig. 8. Fig. 8 is a cross-sectional view showing the essential part of a conventional organic electroluminescence element.

[0006] As is shown in Fig. 8, the organic electroluminescence element includes an anode 52 comprising a transparent electro-conductive film such as ITO formed by sputtering or resistive heating vapor deposition on a substrate 51 made of, for example glass, a hole transport layer 53 made of, for example, N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-diphenyl-4,4'-diamine (which will be abbreviated as TPD hereinafter) similarly formed by resistive heating vapor deposition on the anode 52, a light emission layer 54 made of aluminum 8-hydroxyquinoline (which will be abbreviated as Alq3 hereinafter) prepared by resistive heating vapor deposition on the hole transport layer 53, and a cathode 55 made of a metallic film with a thickness of 100 to 300 nm formed by resistive heating vapor deposition on the light emission layer 54.

[0007] When a dc voltage or dc current is applied to the organic electroluminescence element having such structure by making the anode 52 a positive electrode and the cathode 55 a negative electrode, holes are injected into the light emission layer 54 from the anode 52 via the hole transport layer 53, and electrons are injected into the light emission layer 54 from the cathode 55. In the light emission layer 54, recombination of the hole and electron takes place; and when an exciton generated by such recombination shifts from the excited state to the ground state, the phenomenon of light emission takes place.

[0008] Generally speaking, in such organic electroluminescence element, the light emitted from the luminescent-material in the light emission layer 54 radiates omni-directionally from the luminescent material as the center, and emerges into the air through the hole transport layer 53, anode 52 and substrate 51. Alternatively, the light once proceeds in the direction opposite to the light emerging direction (the direction

toward the substrate 51), is reflected at the cathode 55, and emerges into the air through the light emission layer 54, hole transport layer 53, anode 52 and substrate 51.

[0009] Regarding the device structure of organic electroluminescence elements, there are some descriptions set forth in U.S. Pat. No. 5,917,280 and U.S. Pat. No. 5,932,895.

[0010]

Patent Document 1: U.S. Pat. No. 5,917,280

Patent Document 2: U.S. Pat. No. 5,932,895

[Shortcomings Resolved by the Invention]

[0011] In an image-forming apparatus based on electrophotographic technology, an exposure unit is provided which irradiates exposure light corresponding to image data onto a photoreceptor having been charged to a pre-determined uniform potential and records an electrostatic latent image on the photoreceptor. As the conventional exposure method for such exposure unit, those based on laser beams or LED arrays are dominant.

[0012] In the case of laser beam exposure, downsizing of the unit is quite difficult since optical parts such as a polygon mirror or lenses occupy large spaces. In the case of LED array exposure, cost reduction of the unit is difficult because the circuit board is expensive.

[0013] Now, with use of the above-described organic electroluminescence element as the light source, these problems can be solved.

[0014] However, since the light emitted from the organic electroluminescence element is diffusive, it has been impossible to achieve a sufficient level of light quantity required to form an image on a photoreceptor with the diffusive light from the conventional element.

[0015] Accordingly, the object of the invention is to provide an organic electroluminescence element capable of emitting a large light quantity and an exposure unit as well as an image-forming apparatus both using the element.

[Means for Resolving the Shortcomings]

[0016] To solve the above-cited object, the organic electroluminescence element of the present invention comprises, on a substrate: an anode which acts as a hole injection electrode; a cathode which acts as an electron injection electrode; a first and a second light emission layers each having a light emission region and being arranged between

the anode and the cathode, the first light emission layer being arranged close to the anode, the second light emission layer being arranged close to the cathode; and a charge generation layer which injects electrons into the first light emission layer and holes into the second light emission layer, the charge generation layer being arranged between the first and second light emission layers, wherein the work function of the charge generation layer is configured higher than the ionization potential of the second light emission layer.

[0017] And, to solve the problem, the organic electroluminescence element of the present invention comprises, on a substrate: an anode which acts as a hole injection electrode; a cathode which acts as an electron injection electrode; a first and a second light emission layers each having a light emission region and being arranged between the anode and the cathode, the first light emission layer being arranged close to the anode, the second light emission layer being arranged close to the cathode; and a charge generation layer which injects electrons into the first light emission layer and holes into the second light emission layer, the charge generation layer being arranged between the first and second light emission layers, wherein the electron affinity of the charge generation layer is configured lower than the electron affinity of the first light emission layer, and wherein the ionization potential of the charge generation layer is configured higher than the ionization potential of the second light emission layer.

[0018] Further, to solve the problem, the organic electroluminescence element of the present invention comprises, on a substrate: an anode which acts as a hole injection electrode; a cathode which acts as an electron injection electrode; a first and a second light emission layers each having a light emission region and being arranged between the anode and the cathode, the first light emission layer being arranged close to the anode, the second light emission layer being arranged close to the cathode; and a charge generation layer which injects electrons into the first light emission layer and holes into the second light emission layer, the charge generation layer being arranged between the first and second light emission layers, wherein the potential difference between the electron affinity of the first light emission layer and the charge generation layer, and the potential difference between the ionization potential of the second light emission layer and the charge generation layer are both configured 0.6 eV or less.

[0019] To solve the problem, the exposure unit of the invention uses one of the organic electroluminescence elements described above as the light source.

[0020] To solve the problem, the exposure unit of the present invention uses an organic electroluminescence element as a light source, the element comprising, on a substrate: an anode which acts as a hole injection electrode; a cathode which acts as an electron injection electrode; a first and a second light emission layers each having a light emission region and being arranged between the anode and the cathode, the first light emission layer being arranged close to the anode, the second light emission layer being arranged close to the cathode; and a charge generation layer which injects electrons into the first light emission layer and holes into the second light emission layer, the charge generation layer being arranged between the first and second light emission layers.

[0021] To solve the problem, the exposure unit of the present invention utilizes, as a light source, an organic electroluminescence element comprising, on a substrate: a plurality of anodes which act as hole injection electrodes; a plurality of cathodes which are arranged alternately with the anodes and act as electron injection electrodes; and a plurality of light emission layers each having a light emission region and arranged between the anode and the cathode.

[0022] Since light emission takes place in a plurality of light emission layers in such apparatuses, the light quantity emitted by the organic electroluminescence element can be enhanced.

[0023] In addition, since the light quantity emitted by a light emission layer increases due to the enhancement of the efficiency of hole as well as electron injection into the light emission layer, the light quantity emitted by the organic electroluminescence element can be enhanced still further.

[Embodiments of the Invention]

[0024] The invention set forth in claim 1 provides an organic electroluminescence element comprising, on a substrate: an anode which acts as a hole injection electrode; a cathode which acts as an electron injection electrode; a first and a second light emission layers each having a light emission region and being arranged between the anode and the cathode, the first light emission layer being arranged close to the anode,

the second light emission layer being arranged close to the cathode; and a charge generation layer which injects electrons into the first light emission layer and holes into the second light emission layer, the charge generation layer being arranged between the first and second light emission layers, wherein the work function of the charge generation layer is configured higher than the ionization potential of the second light emission layer. Since light emission takes place in the plural light emission layers, the invention has an effect of enabling the emission light quantity of the organic electroluminescence element to increase. Moreover, since the work function of the charge generation layer is set higher than the ionization potential of the light emission layer lying close to the cathode, the efficiency of hole injection to the light emission layer lying close to the cathode increases, leading to an increase of the light quantity emitted by the light emission layer lying close to the cathode. As a result, the invention has an effect of further enhancing the emission light quantity of the organic electroluminescence element.

[0025] The invention set forth in claim 2 provides an organic electroluminescence element comprising, on a substrate: an anode which acts as a hole injection electrode; a cathode which acts as an electron injection electrode; a first and a second light emission layers each having a light emission region and being arranged between the anode and the cathode, the first light emission layer being arranged close to the anode, the second light emission layer being arranged close to the cathode; and a charge generation layer which injects electrons into the first light emission layer and holes into the second light emission layer, the charge generation layer being arranged between the first and second light emission layers, wherein the electron affinity of the charge generation layer is configured lower than the electron affinity of the first light emission layer, and wherein the ionization potential of the charge generation layer is configured higher than the ionization potential of the second light emission layer. Since light emission takes place in the plural light emission layers, the invention has an effect of enabling the emission light quantity of the organic electroluminescence element to increase. Moreover, since the electron affinity of the charge generation layer is set lower than that the light emission layer lying close to the anode, and the ionization potential of the charge generation layer higher than that of the light emission layer lying close to the

cathode, the efficiencies of hole and electron injections to each light emission layer increase, leading to an increase of the light quantity emitted by these light emission layers. As a result, the invention has an effect of further enhancing the emission light quantity of the organic electroluminescence element.

[0026] The invention set forth in claim 3 provides an organic electroluminescence element comprising, on a substrate: an anode which acts as a hole injection electrode; a cathode which acts as an electron injection electrode; a first and a second light emission layers each having a light emission region and being arranged between the anode and the cathode, the first light emission layer being arranged close to the anode, the second light emission layer being arranged close to the cathode; and a charge generation layer which injects electrons into the first light emission layer and holes into the second light emission layer, the charge generation layer being arranged between the first and second light emission layers, wherein the potential difference between the electron affinity of the first light emission layer and the charge generation layer, and the potential difference between the ionization potential of the second light emission layer and the charge generation layer are both configured 0.6 eV or less. Since light emission takes place in the plural light emission layers, the invention has an effect of enabling the emission light quantity of the organic electroluminescence element to increase. Moreover, by adopting such a configuration, the efficiencies of hole and electron injections to each light emission layer increase, leading to an increase of the light quantity emitted by these light emission layers. As a result, the invention has an effect of further enhancing the emission light quantity of the organic electroluminescence element.

[0027] The invention set forth in claim 4 provides the organic electroluminescence element according to one of claims 1, 2, and 3, in which the charge generation layer comprises at least a first generation layer lying in the side of the first light emission layer and a second generation layer lying in the side of the second light emission layer, wherein the first generation layer is configured at a lower electron affinity compared to that of the second generation layer, and the second generation layer is configured at a higher ionization potential compared to that of the first generation layer. Since the efficiencies of hole and electron injections to each light emission layer increase, an

increase of the light quantity emitted by these light emission layers results. Thus, the invention has an effect of further enhancing the emission light quantity of the organic electroluminescence element.

[0028] The invention set forth in claim 5 provides the organic electroluminescence element according to claim 4, wherein the generation layer which is first fabricated is prepared by resistive heating, and has a capability of alleviating damaging during film formation.

[0029] The invention set forth in claim 6 provides the organic electroluminescence element according to one of claims 1 through 5, wherein the charge generation layer is made of a dielectric material and the relative permittivity of the charge generation layer is larger than that of the first and second light emission layers, and has an effect of enabling the emission light quantity of the organic electroluminescence element to increase.

[0030] The invention set forth in claim 7 provides the organic electroluminescence element according to one of claims 1 through 6, wherein the first light emission layer and the second light emission layer are mutually made of the same material, and has a capability of enabling the increase of the light quantity emitted by the organic electroluminescence element.

[0031] The invention set forth in claim 8 provides an exposure unit which uses the organic electroluminescence element according to one of claims 1 thorough 7 as a light source, and has the capability of achieving a level of light quantity required for exposure without making the unit large in size owing to the organic electroluminescence element with a large emission light quantity.

[0032] The invention set forth in claim 9 provides an exposure unit which uses an organic electroluminescence element as a light source, the element comprising, on a substrate: an anode which acts as a hole injection electrode; a cathode which acts as an electron injection electrode; a first and a second light emission layers each having a light emission region and being arranged between the anode and the cathode, the first light emission layer being arranged close to the anode, the second light emission layer being arranged close to the cathode; and a charge generation layer which injects electrons into the first light emission layer and holes into the second light emission

layer, the charge generation layer being arranged between the first and second light emission layers. The invention has the capability of achieving a level of light quantity required for exposure without making the unit large in size owing to the organic electroluminescence element in which light emission takes place in plural light emission layers and which thus exhibits a large emission light quantity.

[0033] The invention set forth in claim 10 provides the exposure unit according to claim 9, wherein the first light emission layer and the second light emission layer are mutually made of the same material, and has the capability of enabling the enhancement of the emission light quantity of the organic electroluminescence element.

[0034] The invention set forth in claim 11 provides the exposure unit according to one of claims 8, 9, and 10, wherein the layer that includes the light emission layers arranged between an initially fabricated electrode and the charge generation layer and that is arranged adjacent to the charge generation layer is made of a high polymer material, and has the capability of alleviating damaging during film formation.

[0035] The invention set forth in claim 12 provides an exposure unit utilizing, as a light source, an organic electroluminescence element comprising, on a substrate: a plurality of anodes which act as hole injection electrodes; a plurality of cathodes which are arranged alternately with the anodes and act as electron injection electrodes; and a plurality of light emission layers each having a light emission region and arranged between the anode and the cathode. Since the exposure unit has at least one anode and one cathode are arranged alternately, the invention has the capability of achieving a level of light quantity required for exposure without making the unit large in size owing to the organic electroluminescence element in which light emission takes place in plural light emission layers and which thus exhibits a large emission light quantity.

[0036] The invention set forth in claim 13 provides the exposure unit according to claim 12, wherein the layer that includes the light emission layer arranged between an initially fabricated electrode and a subsequently fabricated electrode is made of a high polymer material, and has the capability of alleviating damaging during film formation.

[0037] The invention set forth in claim 14 provides the exposure unit according to one of claims 8 through 13, wherein the organic electroluminescence element is driven by one of alternating current, alternating voltage and wave pulse. The invention has the

capability of achieving a level of light quantity required for exposure without making the unit large in size owing to the organic electroluminescence element in which light emission takes place in plural light emission layers and which thus exhibits a large emission light quantity.

[0038] The invention set forth in claim 15 provides the exposure unit according to claims 8 through 14, wherein an exposure light is retrieved from a side of the organic electroluminescence element. The invention has the capability of achieving a level of light quantity required for exposure without making the unit large in size owing to the organic electroluminescence element in which light emission takes place in plural light emission layers and which thus exhibits a large emission light quantity.

[0039] The invention set forth in claim 16 provides an image-forming apparatus comprising: the exposure unit according to one of claims 8 through 15; and a photoreceptor in which an electrostatic latent image is formed by the exposure unit. Since the exposure unit utilizes the organic electroluminescence element in which light emission takes place in plural light emission layers and which thus exhibits a large emission light quantity, using the exposure unit for an image-forming apparatus results in a compact apparatus.

[0040] In the following, embodiments of the present invention will be explained with references to Figs. 1 – 7. In these figures, the same numerical reference is given to the same part and duplicated explanations are omitted.

(First Embodiment)

[0041] Fig. 1 is a schematic view showing the configuration of a color image-forming apparatus in the first embodiment of practicing the invention. Fig. 2 is an explanatory drawing showing in detail the exposure part of the color image-forming apparatus depicted in Fig. 1. Fig. 3 is an explanatory drawing showing in detail the photoreception part of the color image-forming apparatus depicted in Fig. 1. Fig. 4 is an explanatory drawing showing in detail the development part of the color image-forming apparatus depicted in Fig. 1. Fig. 5 is a cross-sectional view showing the essential part of an organic electroluminescence element used as the light source of the exposure part depicted in Fig. 2. And, Fig. 6 is a cross-sectional view showing the essential part of another modified example of the organic electroluminescence element used as the light

source of the exposure part depicted in Fig. 2.

[0042] In Fig. 1, the color image-forming apparatus 1 is provided with development parts 2, 3, 4 and 5 arranged sequentially each acting to form a color toner image of yellow (Y), magenta (M), cyan (C) or black (K), and further with exposure parts (exposure units) 6, 7, 8 and 9, and photoreception parts 10, 11, 12 and 13 each corresponding to each development part 2, 3, 4 or 5.

[0043] As is depicted in Fig. 2, the exposure parts 6 to 9 are equipped with head supporting members 6a, 7a, 8a and 9a, organic electroluminescence elements 6d, 7d, 8d and 9d each of which acts as a light source and mounted on a support 6b, 7b, 8b or 9b and sealed air-tight with a sealing member 6c, 7c, 8c or 9c provided on head supporting members 6a, 7a, 8a and 9a, and drivers 6e, 7e, 8e and 9e which are mounted on the supports 6b, 7b, 8b and 9b and supply voltage corresponding to image data to the organic electroluminescence elements 6d to 9d to cause the elements to emit light. Furthermore, on the substrates 6b, 7b, 8b and 9b, there are mounted prisms 6f, 7f, 8f and 9f which deflect the light emitted from the organic eletroluminescence elements 6d to 9d, fiber arrays 6g, 7g, 8g and 9g which collect the lights from the prisms 6f to 9f, and cylindrical lenses 6h, 7h, 8h and 9h which collect the light from the fiber arrays 6g to 9g to the sub-scanning direction.

[0044] As is depicted in Fig. 3 in detail, the photoreception parts 10 to 13 comprise photoreceptor drums (photoreceptors) 10a, 11a, 12a and 13a as rotatable image carriers, and chargers (charging means) 10b, 11b, 12 band 13b which are placed impressed contact with the photoreceptor drums 10a to 13a and charge the surface of the photoreceptor drums 10a to 13a to a uniform potential, and cleaners 10c, 11c, 12c and 13c which remove the toner remaining on the photoreceptor drums 10a to 13a after image transfer.

[0045] The photoreceptor drums 10a to 13a which rotate in the circumferential direction are arranged in a line in such a manner that the rotating shafts are in parallel to each other. The chargers 10b to 13b in pressed contact with the photoreceptor drums 10a to 13a rotate along with the rotation of the photoreceptor drums 10a to 13a.

[0046] As is shown in detail in Fig. 4, the development parts 2 to 5 comprise development rollers (developing means) 2a, 3a, 4a and 5a which deposit toner on the

photoreceptor drums 10a to 13a each bearing an electrostatic latent image on its outer surface by the action of the light emitted from the exposure parts 6 to 9 and convert the electrostatic latent images to visible ones, agitation members 2b, 3b, 4b and 5b which agitate toner 14 in tanks, supply rollers 2c, 3c, 4c and 5c which supply toner 14 to the development rollers 2a to Sa under agitation, and doctor blades 2d, 3d, 4d and 5d which adjust the layers of toner 14 supplied onto the development rollers 2a to 5a to a pre-determined thickness and charge toner 14 by friction.

[0047] As is shown in Fig. 1, at the positions facing these exposure parts 6 to 9, the photoreception parts 10 to 13 and the development parts 2 to 5, a transfer part 15 is arranged at which each toner image developed on one of the photoreceptor drums 10a to 13a is transferred onto a paper sheet (recording medium) P in superposition on each other to give a color toner image.

[0048] Each transfer part 15 is provided with a transfer roller 16, 17, 18 or 19 arranged to face each of the photoreceptor drums 10a to 13a, and spring 20, 21, 22 or 23 each of which presses each of the transfer rollers 16 to 19 onto each of the photoreceptor drums 10a to 13a.

[0049] In the opposite side of the transfer part 15, a paper-feeding part 24 which stocks paper sheets P is provided. And paper sheets Pare taken out one by one from the paper-feeding part 24 by means of a paper-feeding roller 25.

[0050] On the paper transport path from the paper-feeding part 24 to the transfer part 15, a pair of registration rollers 26 is provided which feeds a paper sheet P to the transfer part 15 at a pre-determined timing. Further, on the paper transport path along which the paper sheet P runs holding the color toner images transferred at the transfer part 15, a fixing part 27 is formed. The fixing part 27 comprises a heating roller 27a and a pressure roller 27b in a pressed contact with the heating roller 27a. The color image transferred on the paper sheet P is fixed onto the paper sheet P by the pressure and heat generated during the nipping rotation with the rollers 27a and 27b.

[0051] In the image-forming apparatus of such configuration, first of all, an electrostatic latent image for the yellow color component of image information is formed on the photoreceptor drum 10a. This latent image is visualized into a yellow toner image on the photoreceptor drum 10a by means of the development roller 2a having the yellow toner.

Meanwhile, the paper sheet P pulled out of the paper-feeding part 24 by means of the paper-feeding roller 25 is fed into the transfer part 15 in exact timing. Then, the sheet is nipped and conveyed by the photoreceptor drum 10a in conjunction with the transfer roller 16, and at this instant the above-described yellow toner image is transferred from the photoreceptor drum 10a.

[0052] During the transfer of the yellow toner image onto the paper sheet P, a latent image for the magenta color component is consequently formed, and is developed visible as a magenta toner image by means of the development roller 3a having the magenta toner. Then, on the paper sheet P onto which the yellow toner image has been transferred, the magenta toner image is transferred in superposed manner on the yellow toner image.

[0053] Further, in a similar way, image formation and transfer are conducted for cyan toner and black toner images, and superimposition of the four-color toner images completes on the paper sheet P.

[0054] Thereafter, the paper sheet P on which a color image has been formed is transported to the fixing part 27. In the fixing part 27, the transferred toner images are fixed onto the paper sheet P by heat, and a full-color image completes on the paper sheet P.

[0055] The paper sheet P, on which the series of color image-forming operations have thus finished, is then exhausted to a paper-exhausting tray 28.

[0056] The organic electroluminescence elements 6d, 7d, 8d and 9d which are the light sources equipped in the exposure parts 6 to 9 each comprise, as shown in Fig. 5, an anode 32 which comprises a transparent electro-conductive film formed on a substrate 31 by, for example, sputtering or resistive heating vapor deposition and acts as a hole injection electrode, and a cathode 33 which has been formed by, for example, resistive heating vapor deposition and acts as an electron injection electrode. Moreover, between the anode 32 and the cathode 33, there are formed a first light emission layer 34 having a light emission region and arranged at the side of the anode 32, and a second light emission layer 35 having a light emission region and arranged at the side of the cathode 33. Between the anode 32 and the first light emission layer 34, a first hole transport layer 36 is formed, and between the charge generation layer 38 and the second light

emission layer 35, a second hole transport layer 37 is formed. In addition, between the first light emission layer 34 and the second light emission layer 35, a charge generation layer 38 which injects electrons into the first light emission layer 34 and injects holes into the second light emission layer 35 is formed.

[0057] When a dc voltage or dc current is applied by making the anode 32 of the organic electroluminescence element of such configuration a positive electrode, and making the cathode 33 a negative electrode, holes are injected into the first light emission layer 34 via the first hole transport layer 36 from the anode 32 along with electron injection from the charge generation layer 38. Into the second light emission layer 35, electrons are injected from the cathode 33, and at the same time holes are injected from the charge generation layer 38 via the second hole transport layer 37. In the first light emission layer 34 and the second light emission layer 35, the holes and electrons injected in this manner recombine, and excitons generated by such recombination cause light emission when the excitons shift from the excited state to the ground state.

[0058] Here, since light emission takes place in plural light emission layers, i.e., the first one 34 and the second one 35, the light quantity emitted from the organic electroluminescence element can be increased.

[0059] In the organic electroluminescence element of such configuration, the light emitted from the luminescent material constituting the light emission regions of the first and second light emission layers 34 and 35 radiates in all directions with the center of the luminescent material, and emerges through the substrate 31. Alternatively, once after emitted towards the direction opposite to the light-emerging direction (direction toward the substrate 31) and reflected by the cathode 33, then the light is irradiated through the substrate 31.

[0060] As a next step, each part composing the organic electroluminescence element will be described.

[0061] As the substrate 31 for the organic electroluminescence element in accordance with the invention, transparent or semi-transparent materials may be used; in cases where the substrate is not used as the light-emerging plane, an opaque material may be used. Any of these materials can be used so long as it has a sufficient strength for

holding the organic electroluminescence element. The definition of transparency or semi-transparency in the invention indicates such a degree of transparency as not to disturb the visual perception of the light emission by the organic electroluminescence element.

[0062] For the substrate 31, materials can be appropriately chosen from inorganic glass including inorganic oxide glass such as, for example, transparent or semi-transparent soda-lime glass, barium/strontium-containing glass, lead glass, aluminosilicate glass, borosilicate glass, barium borosilicate glass and quartz glass, inorganic fluoride glass, high polymer films made of transparent or semi-transparent poly(ethylene terephthalate), polycarbonate, poly(methyl methacrylate), poly(ether sulfone), poly(vinyl fluoride), polypropylene, polyethylene, acrylate polymer, amorphous polyolefin and fluorine-containing resin, chalcogenide glass such as transparent or semi-transparent As_2S_3, $As_{40}S_{10}$ and $S_{40}Ge_{10}$, metal oxides and nitrides such as ZnO, Nb_2O_5, Ta_2O_5, SiO, Si_3N_4, HfO_2 and TiO_2, semiconductor materials such as opaque silicon, germanium, silicon carbide, gallium arsenide and gallium nitride, transparent substrate materials enumerated above containing a pigment, and metal material which surface has been subjected to insulation treatment. In addition, laminated substrates resulting from stacking a plurality of substrate materials may also be used.

[0063] Further, on the surface of or within such a substrate, a circuit may be fabricated that comprises a resistor, condenser, inductor, diode or transistor and drives the organic electroluminescence element.

[0064] Still further, depending on the application, such materials as to transmit light only in a specified wavelength region or have a light-to-light conversion capability and convert impinging light to the one with a specified wavelength may be used. As for the resistivity of the substrate, though the substrate is preferably an insulator, there is no specific restriction, and the substrate should have a resistivity in the range not to hinder the driving of the organic electroluminescence element. In certain applications, the substrate may be electrically conductive.

[0065] As the anode 32 for the organic electroluminescence element, ITO (indium tin oxide), ATO (Sb doped SnO_2) and AZO (Al doped ZnO) can be used.

[0066] In the present embodiment, the hole transport layer 36 (37) and the light

emission layer 34 (35) form an individual organic thin film layer of a double layer structure. In addition to such a structure, various structures may be adopted including a monolayer structure consisting of only a light emission layer, a double layer structure consisting of a light emission layer and an electron transport layer or a three-layer structure consisting of a hole transport layer, a light emission layer and an electron transport layer. Specifically, there may be used a structure in which, between the two electrodes of an anode 32 and an cathode 33, light emission layers 34 and 35 are provided with an intervening charge generation layer 38 without providing hole transport layers 36 and 37, or another structure in which only one of the hole transport layers 36 and 37 in Fig. 5 is provided. Further, still another structure may be used in which, without forming the second hole transport layer 37 in Fig. 5, a second light emission layer 35 is arranged at the position of the second hole transport layer 37 and in which an electron transport layer is formed at the position of the second light emission layer 35 in Fig. 5. Moreover, in Fig. 5, between the second light emission layer 35 and the cathode 33, an electron transport layer may be provided, or between the first light emission layer 34 and the charge generation layer 38, an electron transport layer may be provided. As has been described heretofore, the essential condition is that, between the two electrodes of anode 32 and cathode 33, at least a first light emission layer 34 and a second light emission layer 35 are formed with an intervening charge generation layer 38. And based on such layer structure, at least either of hole transport layers 36 or 37 may be arranged close to the anode (32) side of the light emission layers 34 and 35 if needed, and at least either of the electron transport layers may be arranged close to the cathode (33) side of the light emission layers 34 and 35 if needed.

[0067] As the light emission layers 34 and 35 of the organic electroluminescence element, materials which have a luminescent or phosphorescent property in the visible region and exhibit a good film-forming property are preferred including, in addition to Alq_3 and Be-benzoquinolinol ($BeBq_2$), benzoxazole-based fluorescent brightening agents such as 2,5-bis(5,7-di-t-pentyl-2-benzoxazolyl)-1,3,4-thiadiazole, 4,4'-bis(5,7-pentyl-2-benzoxazolyl)stilbene, 4,4'-bis[5,7-di(2-methyl-2-butyl)-2-benzoxazolyl]stilbene, 2,5-bis(5,7-di-t-pentyl-2-benzoxazolyl)-thiophine, 2,5-bis(5-α,α-dimethylbenzyl)-2-benzoxazolyl)thiophene, 2,5-bis[5,7-di-(2-methyl-2-butyl)-2-benzoxazolyl]-3,4-

diphenylthiophene, 2,5-bis(5-methyl-2-benzoxazolyl)thiophene, 4,4'-bis(2-benzoxazolyl)biphenyl, 5-methyl-2-[2-[4-(5-methyl-2-benzoxazolyl)phenyl]vinyl]benzoxazolyl and 2-[2-(4-chlorophenyl)vinyl]naphtho[1,2-d]oxazole; benzothiazole-based fluorescent brightening agents such as 2,2'-(p-phenylenedivinylene)-bis-benzothiazole; benzimidazole-based fluorescent brightening agents such as 2-[2-[4-(2-benzimidazolyl)phenyl]vinyl]benzimidazole and 2-[2-(4-carboxyphenyl)vinyl]benzimidazole; 8-hydroxyquinoline-based metal complexes such as aluminum tris(8-quinolinol), magnesium bis(8-quinolinol), zinc bis(benzo[f]-8-quinolinol), aluminum oxide bis(2-methyl-8-quinolinolate), indium tris(8-quinolinol), aluminum tris(5-methyl-8-quinolinol), lithium 8-quinolinol, gallium tris(5-chloro-8-quinolinol), calcium bis(5-chloro-8-quinolinol) and poly[zinc-bis(8-hydroxy-5-quinolinonyl)methane]; metal chelated oxynoid compounds such as dilithium epindolidione; styrylbenzene-based compounds such as 1,4-bis(2-methylstyryl)benzene, 1,4-(3-methylstyryl)benzene, 1,4-bis(4-methylstyryl)benzene, distyrylbenzene, 1,4-bis(2-ethylstyryl)benzene, 1,4-bis(3-ethylstyryl)benzene and 1,4-bis(2-methylstyryl)2-methylbenzene; distyrylpyrazine derivatives such as 2,5-bis(4-methylstyryl)pyrazine, 2,5-bis(4-ethylstyryl)pyrazine, 2,5-bis[2-(1-naphthyl)vinyl]pyrazine, 2,5-bis(4-methoxystyryl)pyrazine, 2,5-bis[2-(4-biphenyl)vinyl]pyrazine and 2,5-bis[2-(1-pyrenyl)vinyl]pyrazine; naphthalimide derivatives, perylene derivatives, oxadiazole derivatives, aldazine derivatives, cyclopentadiene derivatives, styrylamine derivatives, coumarine derivatives, and aromatic dimethylidyne derivatives. Moreover, anthracene, salicylic acid salt, pyrene and coronene can be used. Alternatively, phosphorescent light-emitting materials such as iridium fac-tris(2-phenylpyridine) or polymeric light-emitting materials such as PPV (poly(p-phenylenevinylene)) and polyfluorene may also be used. The first light emission layer 34 and the second one may be composed of the same material or different ones.

[0068] As the hole transport layers 36 and 37 of the organic electroluminescence element, materials which exhibit a large hole mobility and a good film-forming property are preferred. Various organic compounds including the following ones can be used in addition to TPD; porphyrin compounds such as porphine, copper tetraphenylporphine, phthalocyanine, copper phthalocyanine and titanium phthalocyanine oxide; aromatic tertiary amines such as 1,1-bis{4-(di-p-tolylamino)phenyl}cyclohexane, 4,4',4"-

trimethyltriphenylamine, N,N,N',N'-tetraquis(p-tolyl)-p-phenylenediamine, 1-(N,N-di-p-tolylamino)naphthalene, 4,4'-bis(dimethylamino)-2,2'-dimethyltriphenylmethane, N,N,N',N'-tetraphenyl-4,4'-diaminobiphenyl, N,N'-diphenyl-N,N'-di-m-tolyl-4,4'-diaminobiphenyl and N-phenylcarbazole; stilbene compounds such as 4-di-p-tolylaminostilbene and 4-(di-p-tolylamino)-4'-[4-(di-p-tolylamino)styryl]stilbene; triazole derivatives, oxadiazole derivatives, imidazole derivatives, polyarylalkane derivatives, pyrazoline derivatives, pyrazolone derivatives, phenylenediamine derivatives, anilamine derivatives, amino-substituted chalcone derivatives, oxazole derivatives, styrylanthracene derivatives, fluorenone derivatives, hydrazone derivatives, silazane derivatives, polysilane- and aniline-based copolymers, oligomers, styrylamine compounds, aromatic dimethylidyne-based compounds, poly-3,4-ethylenedioxythiophene (PEDOT) or poly-3-methylthiophene (PMeT). Also, a polymer dispersion-type hole transport layer can be used in which a low molecular weight organic material used for hole transport layers is dispersed in a high polymer material such as polycarbonate. These hole transport materials can be used as a hole injection materials or an electron blocking materials, too.

[0069] As the electron transport layer for the organic electroluminescence element, oxadiazole derivatives such as 1,3-bis(4-tert-butylphenyl-1,3,4-oxadiazolyl)phenylene (OXD-7), anthraquinodimethane derivatives, diphenylquinone derivatives and a polymer material comprising an oxadiazol derivative can be used. These electron transport materials can be used as electron injection materials or hole blocking materials, too.

[0070] As the cathode 33 for the organic electroluminescence element, metals or alloys with a low work function are used including metals such as Al, In, Mg and Ti, magnesium alloys such as Mg-Ag alloys and Mg-In alloys, aluminum alloys such as Al-Li alloys, Al-Sr alloys and Al-Ba alloys.

[0071] As the charge generation layer 38 of the organic electroluminescence element, material such as ITO (indium-tin oxide) may be used. In addition to the above-cited materials, various materials such as conductors, semi-conductors, dielectrics and insulators can also be used for the charge generation layer.

[0072] In an organic electroluminescence element having a structure described heretofore, when the charge generation layer 38 is made of a conductor, the work

function of the charge generation layer 38 is set higher than the ionization potential of the second light emission layer 35. Alternatively, when the charge generation layer 38 is made of a semiconductor, dielectric or insulator, it is desirable to configure the electron affinity of the charge generation layer 38 to be lower than the electron affinity of the first light emission layer 34, and the ionization potential of the charge generation layer 38 to be higher than the ionization potential of the second light emission layer 35.

[0073] Such configuration is due to the following mechanism. When the electron affinity of the charge generation layer 38 is lower than that of the first light emission layer 34, the efficiency of electron injection from the charge generation layer 38 to the first light emission layer 34 is enhanced, and when the work function of the charge generation layer 38 is higher than the ionization potential of the second light emission layer 35, or when the ionization potential of the charge generation layer 38 is higher than the ionization potential of the second light emission layer 35, the efficiency of hole injection from the charge generation layer 38 to the second light emission layer 35 is enhanced. Accordingly, the quantities of light emitted from the first light emission layer 34 and the second one 35 increase, resulting in a further increase of the emitted light quantity of the organic electroluminescence element.

[0074] In the case where the charge generation layer 38 is made of an inorganic material, it is ordinary that the ionization potential of the second light emission layer 35 is higher than that of the charge generation layer 38. Under such condition, the efficiency of hole injection from the charge generation layer 38 to the second light emission layer 35 can be made high without lowering the hole injection efficiency by making the potential difference between the two layers as small as possible, specifically, for example, 0.6 eV or smaller, even when the ionization potential of the charge generation layer is lower than that of the second light emission layer.

[0075] And, by adopting such an organic electroluminescence element as the light source for an exposure part, it is possible to attain a level of light quantity required for image exposure without making the apparatus bulky.

[0076] Moreover, using such an exposure unit for an image-forming apparatus results in a compact apparatus.

[0077] As shown in Fig. 6, the charge generation layer 38 can be a double-layer

structure comprising a first generation layer 38a arranged close to the first light emission layer 34 and a second generation layer 38b arranged close to the second light emission layer 35, or a multi-layer structure comprising still more layers.

[0078] In such multi-layer structures, it is preferred to set the electron affinity of the first generation layer 38a lower than that of the second generation layer 38b, and the ionization potential of the second generation layer 38b higher than that of the first generation layer 38a.

[0079] Further, the layer which is first fabricated in the form of film (the first generation layer 38a or the second one 38b) is preferably fabricated by resistive heating in order to avoid the damaging of the first light emission layer 38a during the film-forming step for forming, for example, the first generation layer 38a on the first light emission layer 34. A generation layer to be fabricated thereafter can be made by sputtering, plazma CVD, ion beam or electron beam deposition.

[0080] In the case where a dielectric material is used for the charge generation layer 38, it is preferred to set the relative permittivity of the charge generation layer 38 larger than those of the first light emission layer 34 and the second one 35. For example, the relative permittivity of the charge generation layer 38 is set at roughly 8 to 10 while the relative permittivities of the first and second light emission layers 34 and 35 are set at about 3.

[0081] In the light emission layer and the hole transport layer arranged between the first fabricated electrode (anode 32 or cathode 33) and the charge generation layer 38 (i.e., the light emission layer 34 and the first hole transport layer 36 when the anode 32 has been fabricated first; and the second light emission layer 35 and the second hole transport layer 37 when cathode 34 has been fabricated first), the one adjacent to charge generation layer 38, in other words, the one adjacent to the charge generation layer 38 in the layers including the light emission layers, should preferably be made of a high polymer material since it is less subject to damaging during the formation of the charge generation layer 38. In the cases of a monolayer structure consisting of a light emission layer, a double-layer structure consisting of a light emission layer and an electron transport layer, and a tri-layer structure consisting of a hole transport layer, a light emission layer and an electron transport layer, the layer adjacent to charge

generation layer 38 is made of a high polymer material in these layers.

(Second Embodiment)

[0082] Fig. 7 is a cross-sectional view showing the essential part of an organic electroluminescence element used as the light source of the exposure part for the color image-forming apparatus in the third embodiment for practicing the invention. For confirmation, in the present embodiment, the configuration and the details of the color image-forming apparatus are the same as depicted in Figs. 1 to 4 used in the first embodiment.

[0083] The depicted organic electroluminescence element as the exposure light source has a structure comprising, provided on a substrate 31, an anode 32, a first hole transport layer 36, a first light emission layer 34, a cathode 33, an insulating layer 39, an anode 32, a second hole transport layer 37, a second light emission layer 35 and another cathode 33, all stacked in turn. In other words, in the structure, the anodes 32 and the cathodes 33 are arranged alternately each with the intervening light emission layer 34 (35) and hole transport layer 36 (37).

[0084] All the anodes and cathodes need not always sandwich the light emission layer or other ones, but, as is exemplified by the spatial relation of the anode 32 to the cathode 33 both being inter-layers in Fig. 7, may sandwich an insulating layer 39, i.e., a layer other than a light emission layer.

[0085] When a dc voltage or dc current is applied by making the anode 32 of the organic electroluminescence element of such configuration a positive electrode, and making the cathode 33 thereof a negative electrode, holes are injected into the first light emission layer 34 via the first hole transport layer 36 from the anode 32 at the substrate 31 side along with electron injection from the cathode 33 lying at the insulating layer 39 side; and into the second light emission layer 35, electrons are injected from the uppermost cathode 33, and at the same time holes are injected from the anode 32 lying at the insulating layer 39 side via the second hole transport layer 37. In the first light emission layer 34 and the second light emission layer 35, the holes and electrons injected in this manner recombine, and excitons generated by such recombination cause light emission when the excitons shift from the excited state to the ground state.

[0086] Accordingly, the light quantity emitted by the organic electroluminescence

element can be increased also with the configuration described above, since light emission takes place in plural light emission layers, i.e., the first and second light emission layers 34 and 35.

[0087] To make sure, the insulating layer 39 may be omitted in some cases. Also in the present embodiment, each of the organic thin film layers assumes a double-layer structure consisting of a hole transport layer 36 (37) and a light emission layer 34 (35). In addition to such configuration, a monolayer structure consisting of a light emission layer, a double-layer structure consisting of a light emission layer and an electron transport layer, and a tri-layer structure consisting of a hole transport layer, a light emission layer and an electron transport layer may also be adopted.

[0088] Moreover, in the case shown in the figure, the two anodes 32 and two cathodes 33 are alternately arranged, but it is sufficient that at least one anode and one cathode are arranged alternately.

[0089] In the present embodiment, the light emission layers and hole transport layers arranged between the first fabricated electrode and the subsequently fabricated one are preferably formulated with high polymer material which is less subject to damaging. In a monolayer structure consisting of a light emission layer, a double-layer structure consisting of a light emission layer and an electron transport layer, and a tri-layer structure consisting of a hole transport layer, a light emission layer and an electron transport layer, any layer of these is preferably made of high polymer material.

[0090] In the description hereinabove, the organic electroluminescence element as the exposure light source is driven by dc; however, it may be driven by ac voltage or ac current, or further by wave pulse.

[0091] Though the exposure light emitted from the organic electroluminescence element emerges from the substrate 31 side, other designs are possible in which the light emerges from the opposite side relative to the substrate 31 (i.e., from the cathode 33 side) or in which the light emerges sideways.

[0092] Though the above explanation has been made for the case where the invention is applied to a color image-forming apparatus, the invention can be applied to a monochromatic (for example, black) image-forming apparatus. In cases where the invention is applied to a color image-forming apparatus, the developing colors are not

restricted to the four colors of yellow, magenta, cyan and black.

[Effect of the Invention]

[0093] Since light emission takes place in a plurality of light emission layers, an effective result that the light quantity emitted by an organic electroluminescence element is enhanced is attained according to the invention.

[Brief Description of the Drawings]

Fig. 1 is a schematic view showing the configuration of a color image-forming apparatus in the first embodiment for practicing the invention.

Fig. 2 is an explanatory drawing showing in detail the exposure part of the color image-forming apparatus of Fig. 1.

Fig. 3 is an explanatory drawing showing in detail the photoreception part of the color image-forming apparatus of Fig. 1.

Fig. 4 is an explanatory drawing showing in detail the development part of the color image-forming apparatus of Fig. 1.

Fig. 5 is a cross-sectional view showing the essential part of the organic electroluminescence element used as the light sources for the exposure part of Fig. 2.

Fig. 6 is a cross-sectional view showing the essential part of a modified example of an organic electroluminescence element used as the light sources for the exposure part of Fig. 2.

Fig. 7 is a cross-sectional view showing the essential part of the organic electroluminescence element used as the light sources for the exposure part of the color image-forming apparatus of the second embodiment for practicing the invention.

Fig. 8 is a cross-sectional view showing the essential part of a conventional organic electroluminescence element.

[Description of the Numerical Characters]

6, 7, 8, 9: exposure parts (exposure units)

6d, 7d, 8d, 9d: organic electroluminescence element

31: substrate

32: anode

33: cathode

34: first light emission layer

35: second light emission layer
36: first hole transport layer
37: second hole transport layer
38: charge generation layer
38a: first generation layer
38b: second generation layer
39: insulating layer